I – Problem Statement Title (04-EQ082)

Development of Seismic Design Guidelines for Segmental Construction

II – Research Problem Statement

Question: Can segmental construction be made a more cost effective construction method, and provide improved post-earthquake serviceability for bridges built in areas of high seismic activity?

Segmental construction is gaining popularity as a method of construction where the local terrain and/or traffic prohibit the erection of conventional false work. Unfortunately the popularity of segmental construction is limited in seismic regions due to bridge specific criteria requiring the superstructure to remain elastic and the plastic hinge to form in the column. Critics claim these criteria are too stringent and reduce the efficiency of the structural and construction processes. Additional testing is needed to ensure performance requirements are achieved, and guidelines are developed for post-earthquake inspection of a segmental bridge subject to inelastic superstructure response.

III – Objective

Develop design criteria / guidelines to allow segmental construction in high seismic zones by allowing yielding and nonlinear response in the superstructure.

IV – Background

Precast segmental construction has evolved over the last fifty years to cope with construction difficulties such as deep valleys and irregular landscapes that prohibit conventional falsework erection, the desire for shorter construction time, and the ever present need for higher quality and more efficient construction processes. The popularity of precast segmental bridges is hampered in high seismic zones due to a lack of standardized design criteria allowing production of such bridges on a larger scale. Previously, a research project was initiated by the American Segmental Bridge Institute (ASBI) and funded by Caltrans to investigate the seismic performance of precast segmental bridges. The project consists of three phases. Seismic performance of the superstructure segment-to-segment joints was investigated in Phases I and II; these two phases were completed at University of California at San Diego (UCSD) as part of RTA #59A0051. The third phase, which consists of a systems test, will be investigated by UCSD as part of RTA No. 59A0337. While the work completed demonstrates the technical feasibility of constructing bridges in high seismic areas, significant work remains in order to develop the design criteria necessary to make this an alternative method for the design sections. For example, much of the research has focused on smaller span structures (i.e., one hundred ft spans) and not the longer spans (i.e., two – three hundred feet) where the method becomes more cost effective. Tests that have successfully demonstrated the inelastic response of the superstructure are based on a single direction event, not a bi-directional event that is more probable during the service life of a structure. Lastly, if segmental bridge superstructures were allowed to yield during a seismic event, inspection protocols are needed to allow Structure Maintenance to assess the live load capacity of the bridge after the earthquake.

V – Statement of Urgency and Benefits

A. Support of the Departments Mission/Goals:

(<u>Improving Mobility</u>: <u>Safety</u> and <u>Reliability</u>) Implementation of this research will improve the Safety, Reliability, Productivity and Performance of the Transportation System by reducing traveler delays due to highway construction, as well as construction costs. Construction with no false work is an appealing benefit in California with its busy highway systems where existing traffic flow continues virtually unabated while construction is underway, and to those locations where inspection of the bridge after a seismic event is difficult. In addition, if proven successful, bridges built using this method should sustain less damage after a seismic event, thus returning the structure to service quality.

B. Return on Investment:

If verified by the research, there could be significant cost savings during construction due to reduced superstructure strength requirements making this bridge type more cost competitive. Even if just one more of these bridges is constructed every three years, if it results in a 10% bridge cost savings, the construction savings would be in the range of several million dollars. Significant additional savings would also be realized during post-earthquake recovery if column damage can be limited, and repair needs are in fact minimal. It is anticipated that tens of millions of dollars could be saved due to reduced economic impacts of just one of these bridges being out of service, in addition to the repair costs. Caltrans must complete this work in order to either implement the method or defend the decision not to implement, to groups outside Caltrans.

VI – Related Research

1. Garg, M., Megally, S.H., Seible, F., and Dowell, R.K., *Seismic Performance of Precast Segmental Bridge Superstructures*, Research Report SSRP-2001/24 (Draft) submitted to Caltrans, University of California at San Diego, CA, December 2001, 297 pp.
2. AASHTO, *Guide Specification for Design and Construction of Segmental Concrete Bridges*, The American Association of State Highway and Transportation Officials, Second Edition, 1999, 78 pp.
3. Hewes, J.T., and Priestley, M.J.N., *Seismic Design and Performance of Precast Concrete Segmental Bridge Columns*, Research Report SSRP-2001/25 (Draft) submitted to Caltrans, University of California at San Diego, CA, December 2001, 230 pp.

4. Rahman, A. and Restrepo, J.I., “Earthquake Resistant Precast Concrete Buildings: Seismic Performance of Cantilever Walls Prestressed with Unbonded Tendons”, Research Report 2000-5, Department of Civil Engineering, University of Canterbury, Christrchurch, New Zealand, 2000.
5. K. Burnell, S. Megally, and J. Restrepo. *Cast-In-Place Hollow Rectangular Column Test, Preliminary Results Summary*. May 7th.

VII – Deployment Potential

If successful, this project will result in design guidelines and revisions to the AASHTO Design Specifications.